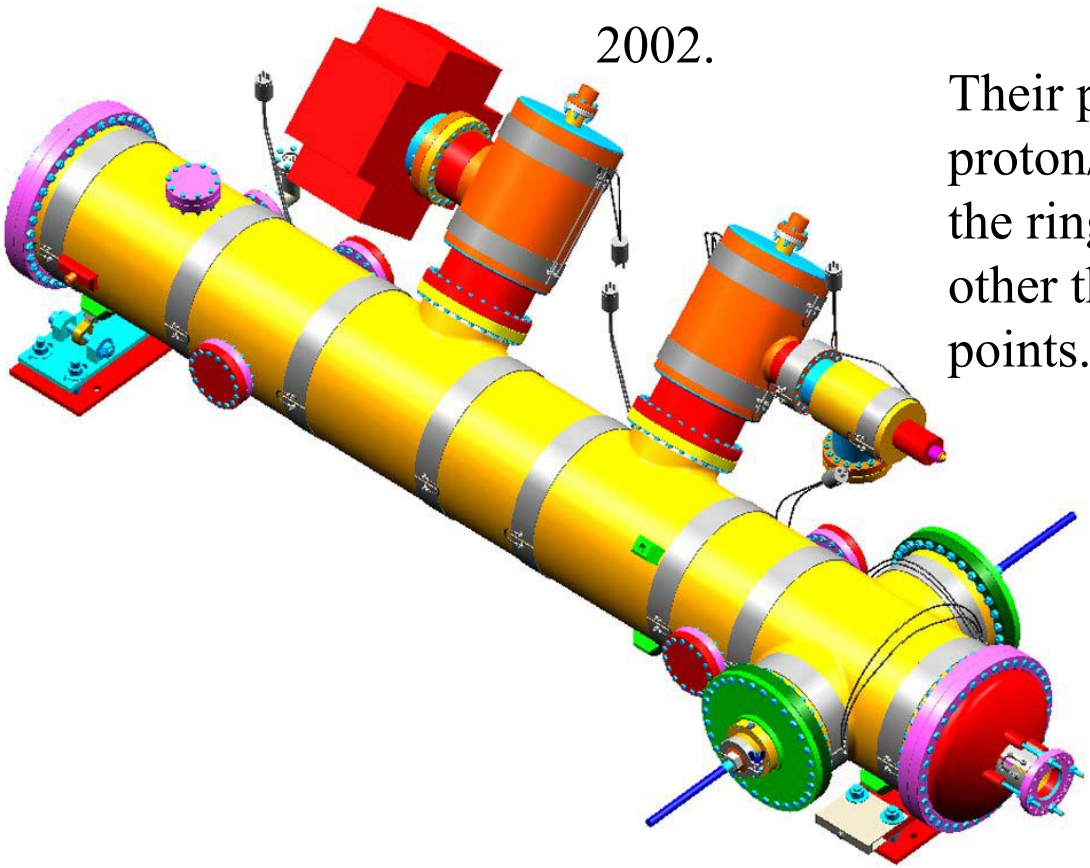
Electrostatic Beam Separator Construction

Electrostatic Beam Separators

Four electrostatic beam separators were built by Technical Division between April and December of 2002.

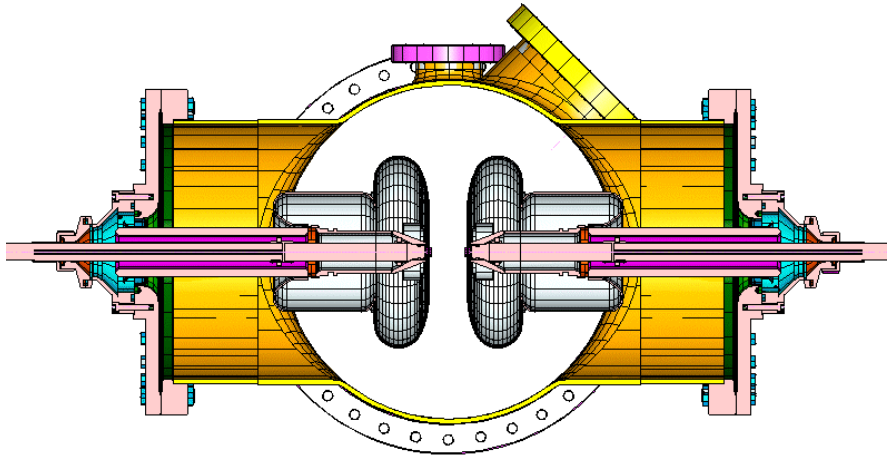


Their purpose is to separate the proton/antiproton beams throughout the ring to prevent collisions at places other than the specified interaction points.

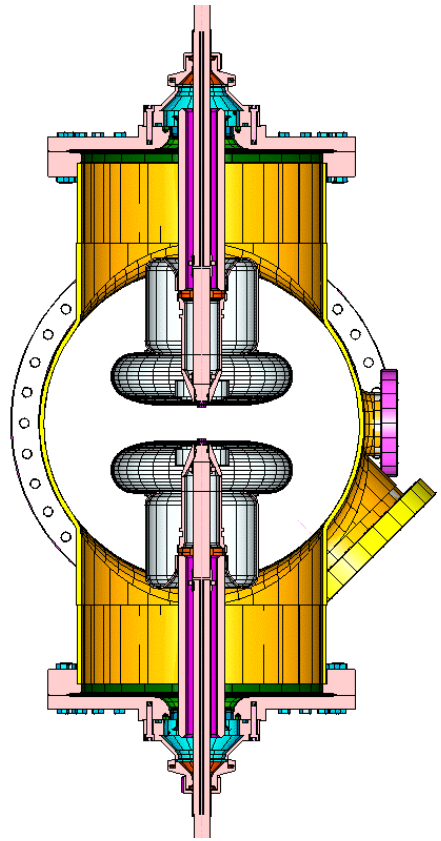
There are presently 21 beam separators in the Tevatron main ring. There are 8 spares, four built by Technical Division and 4 previously existing.

Electrostatic Beam Separator Construction

Horizontal and Vertical Separators



Horizontal Orientation

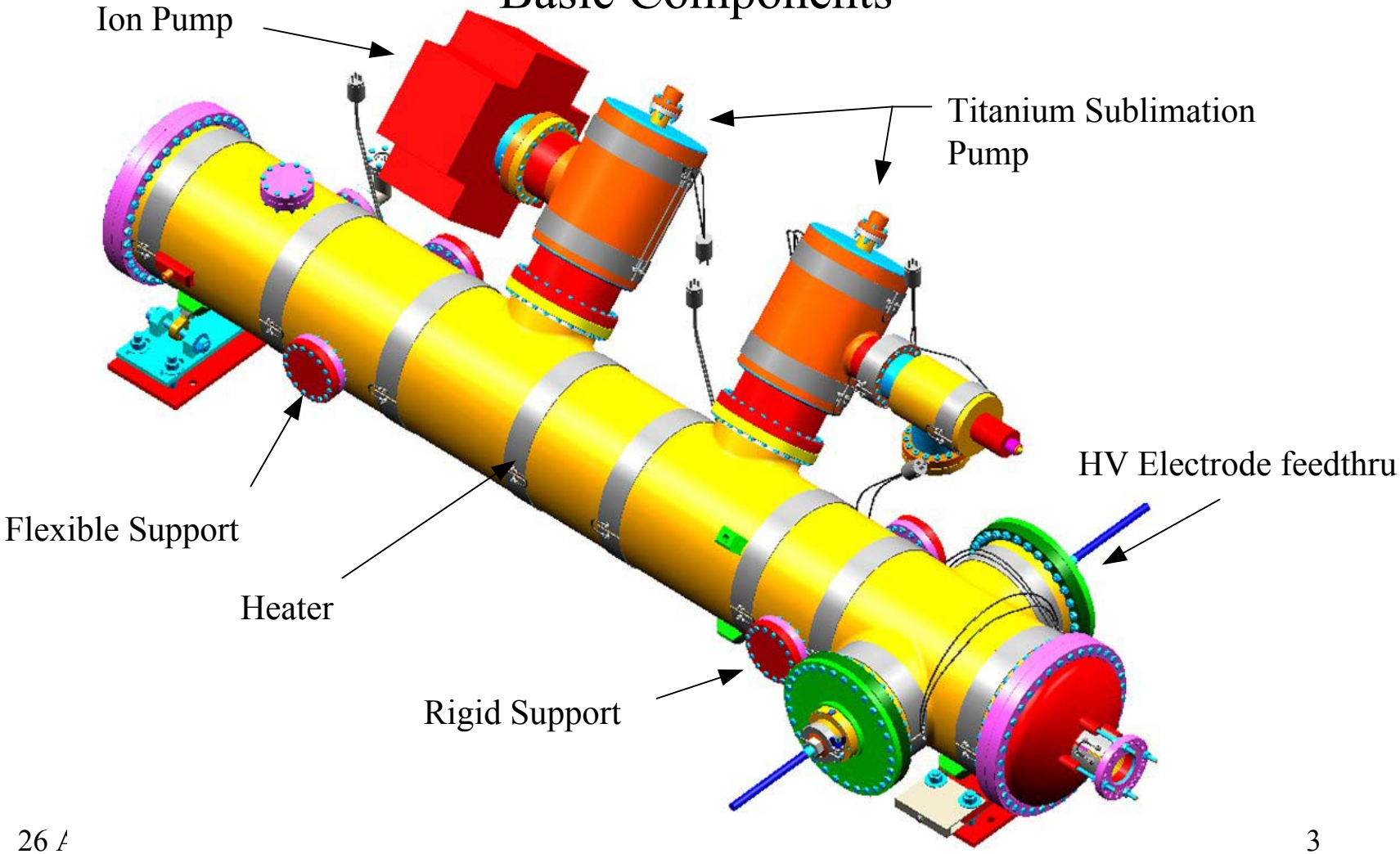


Vertical Orientation

Electrostatic Beam Separators consist of two "parallel plates", separated by 5mm, with a potential difference of 200kv DC between them. They can be constructed in two different configurations, "horizontal" and "vertical". The parts for each type are identical, just assembled differently depending on the configuration.

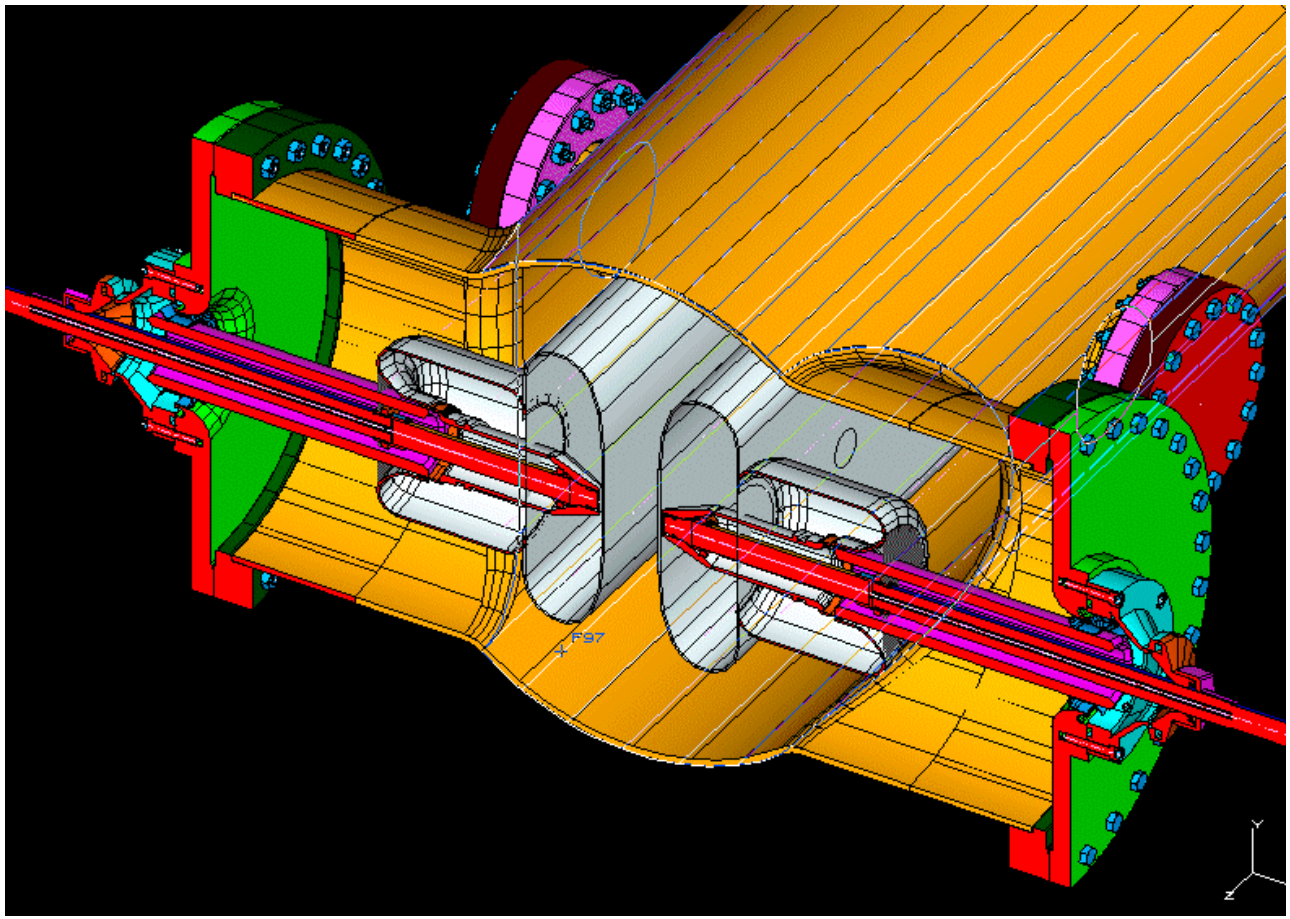
Electrostatic Beam Separator Construction

Basic Components



Electrostatic Beam Separator Construction

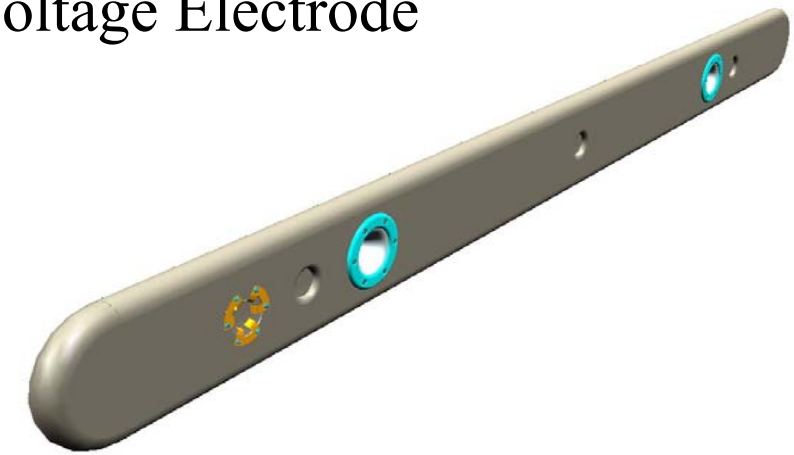
High Voltage Electrode Assembly Isometric



Electrostatic Beam Separator Construction

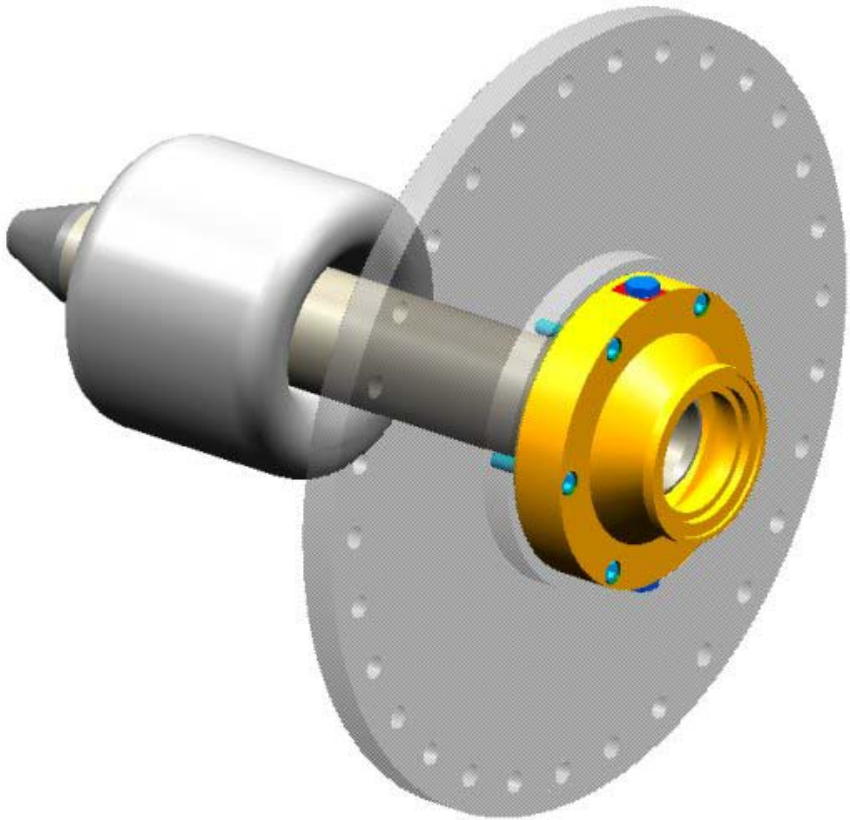
High Voltage Electrode

The electrode is made of 304 stainless steel. The exterior surface is polished to a surface finish of 4-8 RMS microinches, to prevent sparks when the separator is at high voltage.



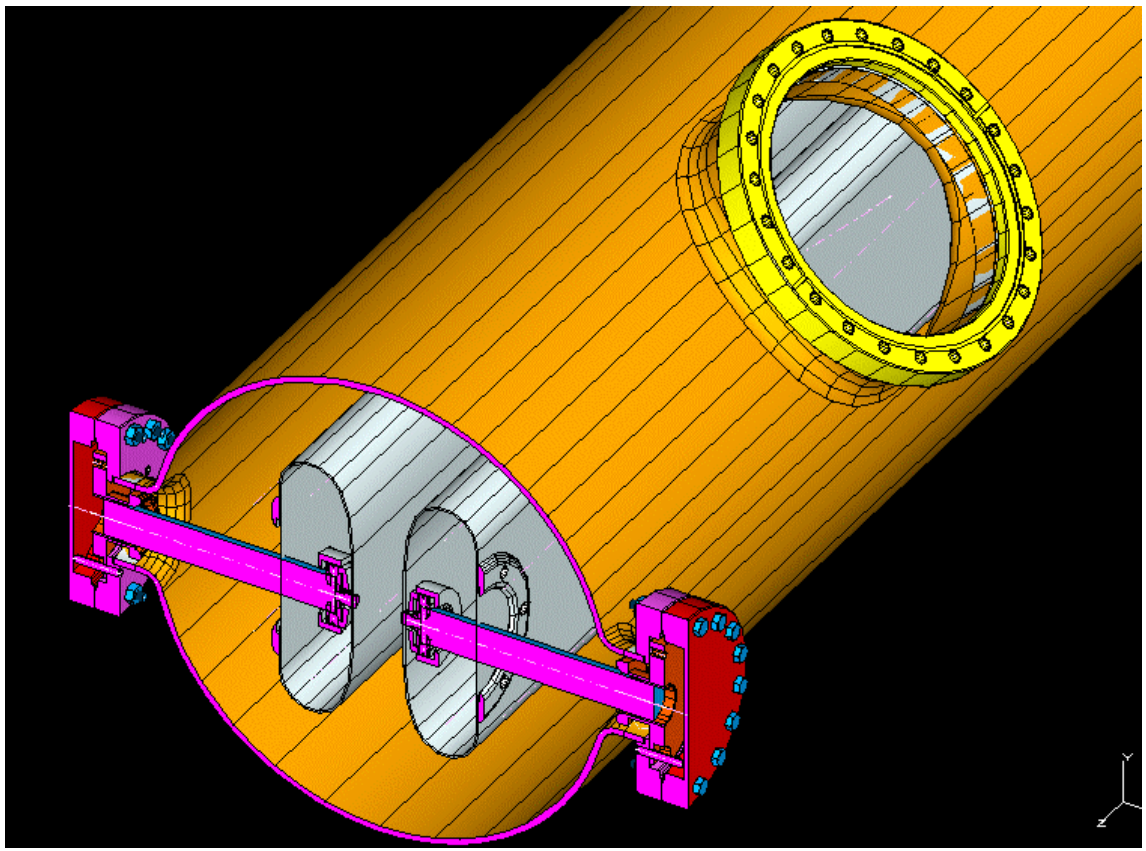
Electrostatic Beam Separator Construction

HV Cable Feedthrough Support Assembly



Electrostatic Beam Separator Construction

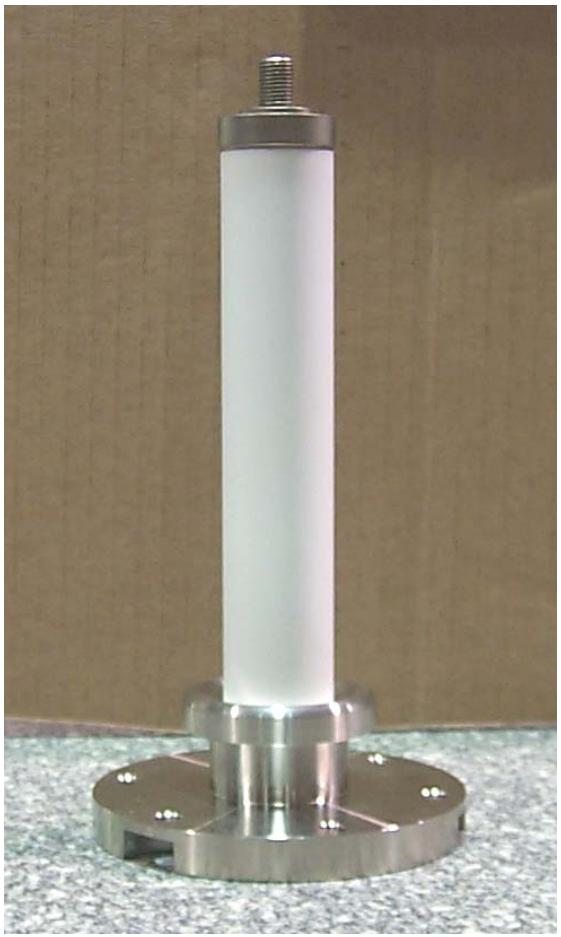
Fixed and Flexible Supports



Each electrode is supported in two places longitudinally. One set of supports is fixed, rigidly supporting the electrode, and one is flexible. The flexible support flexes in two places, both in the longitudinal plane, to allow for differential thermal contraction between separator parts. The distance between the electrodes must be between 50mm and 50.5mm when the separator is installed.

Electrostatic Beam Separator Construction

Fixed and Flexible Supports

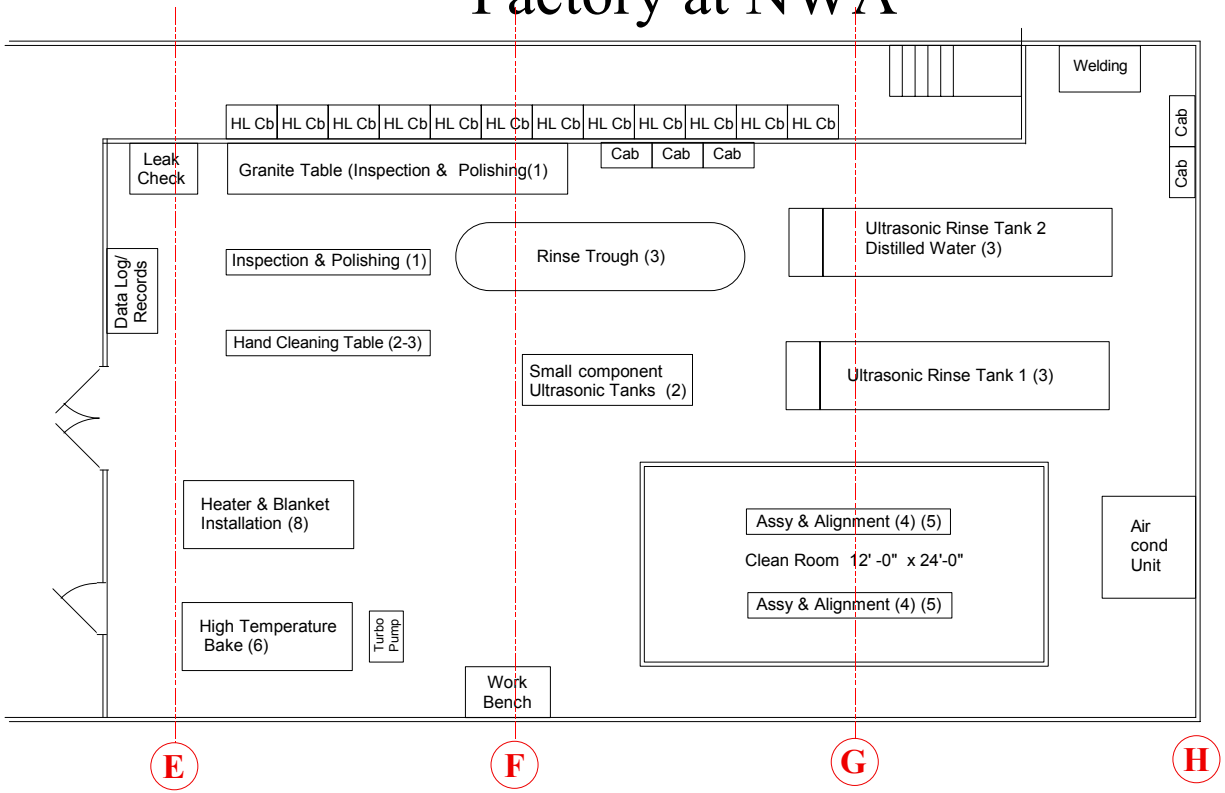


Electrostatic Beam Separator Construction

Support Nose Assembly

Electrostatic Beam Separator Construction

Factory at NWA



The factory for building beam separators is at NWA, "owned" by the Beams Division. This factory was set up by a combination of TD and BD personnel in 2002. It remains in place at NWA to build or repair future beam separators or other devices.

Electrostatic Beam Separator Construction

Personnel

Project team consisted of:

- Jim Walton – Engineer
- Rodger Bossert – Engineer
- Don Mitchell - Engineer
- Dean Sorenson – Lead Technician
- Jim McCausland – Technician
- Don Lewis – Technician
- Adam Levy - Technician
- John Sachtschale – Design & Drafting
- Les Peters – Fabrication
- Bob Jensen – Traveler Coordinator
- Inspection crew

Conditioning “cave”, consisting of a blockhouse within NWA, was built by Beams Division personnel under the supervision of Dave Augustine. It is presently in operation, conditioning the first of four separators.

Electrostatic Beam Separator Construction

Assembly of Separators

Inspection and Preparation of Parts:

1. Count and inspect parts – done by TD material control department.
2. Construct subassemblies.
3. Preliminary leak check of vacuum vessels and subassemblies (to sensitivity of 5×10^{-9} std. cc/sec.
4. Preliminary "white glove" inspection of electrodes.
5. Polish electrodes if necessary.
6. Do any necessary hand polishing of other parts.
7. Ultrasonic cleaning of parts.

All parts are "pre-cleaned" by hand with ethyl alcohol. Large parts cleaned in large ultrasonic tanks containing 2% micro 90 fluid at 110F for 4 hours, then rinsed with distilled water and dried with nitrogen. Large tanks are 3 ft. wide x 12 ft. long. Small parts may be cleaned in large or small tanks. Small parts are bagged with nitrogen until ready for use.

Electrostatic Beam Separator Construction

Ultrasonic Cleaning Tanks at NWA

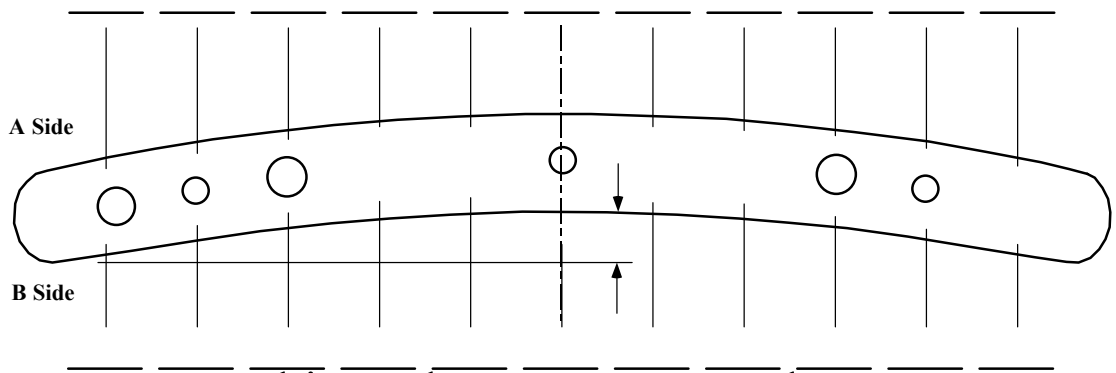
Electrostatic Beam Separator Construction

Clean room at NWA

Electrostatic Beam Separator Construction

Assembly of Separators

8. Map electrode surfaces and define reference plane.



9. Move vacuum vessel into clean room. Level Vacuum Vessel in x and z
10. Move electrodes into clean room. Set them on parallel bars to level them by the reference plane.
11. Pre-installation of fixed and rigid supports into electrodes. The attachment cones need to be leveled in x to ensure that the supports are perpendicular to the electrodes. Then the supports are shimmed at the nose to achieve the proper "clocking" with respect to the flange on the vacuum vessel.

Electrostatic Beam Separator Construction

Assembly of Separators

12. Installation and alignment of electrodes. Done with the separator in the vertical position. Electrodes are first loosely installed using the support assemblies. Then aligned optically using the reference planes, each individually to 2.5 cm (.987 in.) within +.25/-.00 mm (+.010/-.000 in.) from the center of vacuum vessel. Distance is achieved by adjusting set screws on back flange of supports.
13. Installation of HV feedthrough assemblies.
14. Blowout with nitrogen and visual inspection.
15. Installation of TSP's, end domes and other covers.
16. Move out of clean room.
17. Installation of Ion Pump.
18. Pre-bakeout leak check to 5 x 10^{-9} atm. cc/sec.
19. Perform Residual Gas Analysis.
20. Baking of assembly at 300C for 72 hours minimum.

Electrostatic Beam Separator Construction

Baking Oven

Electrostatic Beam Separator Construction

Assembly of Separators

21. Titanium sublimation pump operation at 150C under vacuum.
22. Ion pump operation at 40C under vacuum.
23. Post-baking leak check of separators. Final measurements vary between 5×10^{-9} and 5×10^{-10}.
24. Electrical testing (conditioning).
25. Heater and blanket installation.
26. Final inspection and shipping.

Electrostatic Beam Separator Construction

Completed Separators with Blankets and Heaters

Electrostatic Beam Separator Construction

Schedule (actual 2002)

4 separators were fabricated in FY2002, between April and December. Approximate time breakdown:

- Factory Setup - 3 months - April through June.
- Preparation of subassemblies and cleaning of parts for all four separators – 3 months – June through August.
- Assembly of first separator – 4 months – July through October.
- Construction of 2^{nd} – 4^{th} separators – 1 month each, 3 months total, October through December.

Electrostatic Beam Separator Construction

Cost and Redesign

• Total cost of parts for one separator (as built) is approximately $80000.

• Original proposal to build 4 separators in 2002 included rework of drawings, travelers, completion and setup of the factory, and labor to build the separators. This included rework and ordering of some parts.

• Post-conditioning tasks were subsequently eliminated. Conditioning, heater and blanket installation still needs to be done. Heaters and blankets for the four separators are stored at NWA.

• Based on the 2002 experience, it will take a similar crew about 8 months to build 4 more separators. Some of these tasks (subassemblies and cleaning of parts) could be concurrent with the fabrication of new, redesigned parts (longer electrodes and vacuum vessels).

Electrostatic Beam Separator Construction

Cost and Redesign

- If longer electrodes are needed, rework of the solid model, some analysis, and redesign of parts will be required. These tasks will require approximately 2-3 months of time for one designer.
- All factory components are in place to build more separators. However, the baking oven is not sufficiently long to accept separators longer than the present design. It would need to be reworked or rebuilt.
- Estimated costs for purchasing new vacuum vessels are $17500 each (from May 2000) with several months lead time.
- Estimated costs for purchasing new (longer) electrodes are $15500 per electrode with more than 6 months lead time.

These costs and times must be added to the resources needed to build redesigned separators.

Electrostatic Beam Separator Construction

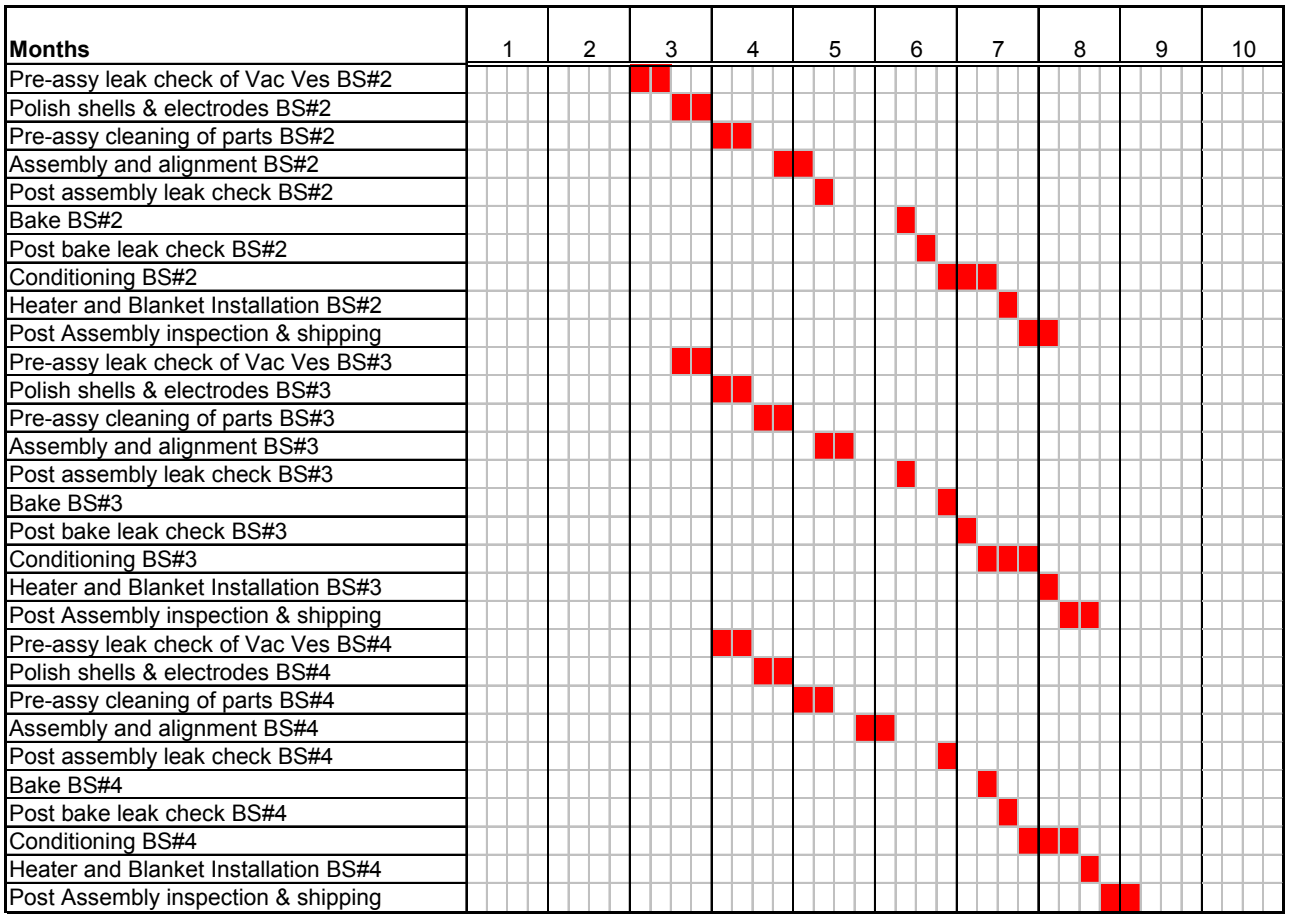
Schedule (proposed) Part 1

Months	1	2	3	4	5	6	7	8	9	10
Needed before Fabrication can begin:										
Design and Drafting	Approximately 3 months, but could order electrodes in less than a month.									
Ordering and receiving new electrodes	More than 6 months									
Ordering and receiving Vac Vessel Ext.	3 months?									
Rework or replace baking oven	3 months.									
Electrostatic Beam Separator Fabrication										
Reclaiming parts from existing separators										
Fabrication of any extra parts										
Inspection of Parts										
Traveler Revisions										
Preparing factory										
Pre-cleaning of subassemblies										
Welding of subassemblies										
Inspection of sub-assembies										
Leak checking of subassemblies										
Stock subassemblies										
Pre-assy leak check of Vac Ves BS#1										
Polish shells & electrodes BS#1										
Pre-assy cleaning of parts BS#1										
Assembly and alignment BS#1										
Post assembly leak check BS#1										
Bake BS#1										
Post bake leak check BS#1										
Conditioning BS#1										
Heater and Blanket Installation BS#1										
Post Assembly inspection & shipping										

This is a proposed schedule, assuming four separators are to be built, and that electrodes and vacuum vessels are available. It is based on past experience from 2002 and assumes the present factory at NWA is available for production.

Electrostatic Beam Separator Construction

Schedule (proposed) Part 2



This is a proposed schedule, assuming four separators are to be built, and that electrodes and vacuum vessels are available. It is based on past experience from 2002 and assumes the present factory at NWA is available for production.

Electrostatic Beam Separator Construction

Polarity Switches

Eight polarity switches were scheduled to be built during FY2003. Drawings have been updated, and are essentially ready to use for fabrication. Total cost of parts is estimated to be approximately $15000 per polarity switch.

Polarity switches could be built by TD personnel, either in NWA or in the Industrial Area.